Draft report of the NOAA Large Whale Health Assessment Workshop held in Olympia, Washington on 8-9 December 2006

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ABSTRACT

A workshop was held on 8-9 December 2006 to review and facilitate the development of field health assessment techniques for free-ranging bowhead, gray and humpback whales. Participants included veterinarians and large whale biologists tasked with 1) reviewing health assessment research to date, 2) attempting to standardize definitions and methodologies and 3) discussing priorities for further work. Since the pioneering work on North Atlantic right whales, several studies have been initiated to visually assess health in free-ranging large whale species. Body condition, especially at the nuchal area, was considered likely to be an important indicator of health in all species examined. Skin condition and ectoparasite load were also considered potentially informative. Laboratory analyses of skin, blubber, breath or feces will likely be required to clarify visual data and carcasses may serve as another important source of ground-truthing information. Finally, the workshop emphasized the importance of a continued dialog among researchers in varied disciplines, as well as comparative studies among species and areas.

INTRODUCTION

On 8-9 December 2006, a workshop was held in Olympia, Washington (USA) to coordinate the development of health assessment techniques for large whale species. The meeting was sponsored by the NOAA Fisheries' Marine Mammal Health and Stranding Program (MMHSP) in partnership with the Hawaiian Island National Marine Sanctuary and organized by Cascadia Research Collective. The goals of the workshop were to review large whale health assessment research to date, to attempt to standardize definitions and methodologies and to discuss priorities for further work. The emphasis was on the advancement of field techniques for bowhead, gray and humpback whales.

Rotstein reviewed approaches to assessing health in mysticetes, including procedures used during large whale strandings and the broad range of analytical techniques available for biopsy-based tissue samples. For free-ranging large whales, visual observations and biopsy samples are currently the most feasible avenues for health assessment.

Visual observations might include descriptions of body condition, skin condition and animal behavior. In the case of skin condition and lesions, standard terms should be adopted from standard necropsy techniques to ensure consistency with other types of assessment. Biopsies obtained in the field can now be sub-sampled for a wide range of analyses relevant to health, including histology, lipid analysis, contaminant analyses, biotoxins, infectious disease screening, hormone assays, nutritional status and proteomics. In addition to skin biopsies, other samples such as feces, exhaled gases, sloughed epithelium, or serendipitous findings such as placentas can provide additional information about individual animals and the overall population.

REVIEW OF CURRENT RESEARCH

North Atlantic right whales

Rolland summarized pioneering work on visual health assessment techniques applied to North Atlantic right whales (*Eubalaena glacialis*). Accurate evaluation of health and predictions of fate are of key conservation interest for this endangered species. Pettis et al. (2004) developed a scoring system based on visible changes in individuals with compromised health (e.g. chronically entangled whales). Four physical parameters were selected for scoring: relative body condition, skin condition, presence of cyamids around the blowholes and rake marks (radiating white lines forward of the blowholes). Initial analyses of over 200,000 images of 410 right whales taken from 1935-2000 were examined and scored for those parameters using a numerical rank scale. All photographic sightings of an individual whale were grouped by habitat and year and scored by a single researcher. To determine the consistency of scoring methodology among different observers, a double blind study was conducted wherein two additional researchers independently scored 100 random collections of photos. There was strong inter-researcher scoring consistency, indicating that the criteria applied had been sufficiently objective.

Pettis et al. (2004) performed two sets of analyses to test the predictive capability of their visual health assessment methodology. Body condition scores of reproductively active females were compared in calving and non-calving years to determine if scoring reflected variation in body condition known to occur throughout the reproductive cycle. Females were scored as significantly thinner while accompanied by a calf (during lactation) and in the year following calving (recovery) compared to the year before calving (pregnancy), consistent with the energetic demands related to calving and nursing events. In the second analysis, the authors compared scores for all parameters for living and "presumed dead" whales (i.e. whales not sighted for more than 5 years). Presumed dead whales consistently received scores indicating compromised health and nine of ten whales scored as emaciated have never been re-sighted, suggesting that poor body condition scores may be useful for predicting survival.

Visual health assessment provides a tool to monitor right whale health at the individual and population level. Management applications of this method include assessing the health status of entangled whales as part of disentanglement action plans. Continuing research focuses on the relationship between health assessment and calving success, predictors of mortality, trends in population-wide health indicators, and the relationship between visual health assessment scores and other health indices.

Fecal sampling has proven to be a particularly useful alternative to biopsy sampling in addressing questions related to health and reproduction in North Atlantic right whales (e.g., Hunt *et al.*, 2003; Hughes-Hanks *et al.*, 2005; Rolland *et al.*, 2005; Doucette *et al.*, 2006; Hunt *et al.*, 2006). However, it was noted in discussion that fecal samples are not as readily obtained for other large whale species.

Bowhead whales

Bowhead whales (*Balaena mysticetus*). have been studied in conjunction with the native Alaskan subsistence hunt in northern Alaska over the past 20 years. Unlike strandings, harvested whales are expected to be in relatively good health at the time of death. Thus, these data provide a baseline on the studied population, as well as insight into "normal" health parameters for large whales. Rosa summarized research on skin lesions, blubber structure and blubber composition. In the 1970's and early 1980's, epidermal lesions had been classified into five groups using gross descriptions only: circular depression, sloughing type, raised roughened areas, roughened flat areas and depressed irregularly shaped areas (Philo et al., 1993). Epidermal lesions were considered benign and self-limiting (J.T. Haldiman, unpublished data), though few were characterized histologically and their cause was undetermined. More recently, various epidermal lesions have been assessed in conjunction with information gathered as part of a

recent bowhead whale health assessment program. Rosa discussed functional and pathological aspects of cetacean skin and the potential impact of different causative agents on mysticete populations.

Blubber is integral to the survival of arctic marine mammal species, including large whales, which employ it for a variety of uses. Bowhead whales have among the most extensive blubber described in cetaceans, reaching a thickness of up to 50 cm and representing nearly 50% of body mass. Rosa described a study of baseline distribution of blubber thickness at six different body sites on 44 individuals. The distribution of collagen and lipid at each of these sites was investigated and an analysis of collagen and lipid at five depths at each of these sites was conducted. Blubber collagen percentage (BCP) did not differ significantly between spring and fall seasons, nor did it differ significantly between sites on the whale. The innermost blubber layer (closest to muscle) contained a significantly higher percentage of collagen than the other four depths. However, there was no difference in BCP found among the other four depths. Both gender and age were found to affect BCP. Females and pregnant females were statistically indistinguishable; however both contained a significantly higher percentage of collagen in their blubber than males. A linear relationship was found between age and BCP (Rosa *et al.*, 2001).

Blubber thickness varied significantly between sampling sites, class and age. Pregnant females had the thickest blubber, compared to non-pregnant females and males as averaged across all sampling sites. Blubber thickness increased significantly with age. Principle components analysis revealed a relationship between blubber thickness and BCP with a marked spatial separation between these two variables and lipid percentage. There was no correlation found between percent lipid and collagen or between percent lipid and blubber thickness, however there was a positive relationship noted between blubber thickness and BCP. The implications of these findings were discussed with respect to the collection of morphometric data and marine mammal health assessment.

Bowhead whale research provides a unique opportunity to ground-truth visual assessments. In the future, it may be possible to visually score carcasses while they are still floating for comparison to data collected after landing. Overall, the relevant directions of further work included an analysis of scarification from aerial-, ice- and boat-based platforms, assessment of skin condition apart from scarring, assessment of cyamid loads based on Pettis et al. (2004) and body condition scoring. There was also interest in a comparison of epidermal lesions between free-ranging and harvested whales. Categorization of lesions into existing classes would likely be attempted, although they may be hard to distinguish from a distance at sea.

Gray whales

Bradford and Weller described an on-going study quantifying body condition in western gray whales, *Eschrichtius robustus*, from photographs. The western gray whale population is critically endangered and its potential for recovery is uncertain. Among other natural and anthropogenic threats, western gray whales are vulnerable to nutritional stress, as evidenced by the regular observation of individual whales in poor body condition. Designing and implementing a protocol to quantify body condition was one means of assessing health for ongoing conservation efforts for the population. A long-term (1994-2005) photo-identification study of western gray whales on their feeding ground off the northeastern coast of Sakhalin Island, Russia, has resulted in a large data set of digital, film, and video images of 150 identified individuals. These images were reviewed and scored for relative body condition of individual whales. Body condition was evaluated on a numerical scale to rank the relative amount of subcutaneous fat in three body locations: 1) the post-cranial area, 2) the scapula regions, and 3) the lateral flanks. Depressions at these locations cause whales to appear 'skinny,' and these whales are generally considered to be in poor body condition. The authors detailed their quantification protocol, and discussed possible research questions, limitations, and implications of the body condition analysis. See SC/59/BRG22 for more detailed results of this research.

Workshop participants considered that ectoparasite load (e.g. barnacles and cyamids), in addition to body condition, might be informative in this species. Some level of ectoparasite coverage was considered normal, but its severity was potentially of interest as well as whether it was confined to local areas. By contrast, skin condition was expected to be difficult to study effectively. It was concluded that body condition should continue to focus on the nuchal/blowhole/post-cranial area, as this part of the body is relatively easy to document and changes can be detected earlier than at other sites on the body. The scapular region and the flanks should continue to be documented for body condition to tie in to historic data. There was concern over differences in appearance of the scapula in relation to body position. Research to date has used video to provide detail that might otherwise be lost in photographs alone.

The small size of the western gray whale population has both advantages and disadvantages for health assessment research. There was clear value to further work on western gray whales, given their current status as well as the intense study and tracking of individuals underway. However, participants recognized the value of parallel research on the eastern gray whale population, where larger population sizes might facilitate inference and provide opportunities for regional and seasonal comparisons. Such work would also allow more opportunities to compare pregnant and lactating females to ascertain normal changes in subcutaneous fat. Weller and Urban planned to collaborate on a protocol for eastern gray whales, working within the general framework of what was already developed for western gray whales.

As in the case of other species, carcasses were identified as a valuable source of validating information and other data. Whereas samples from compromised whales can be obtained from strandings, participants wondered about the availability of data from subsistence harvests of eastern gray whales in Russia to serve as a baseline. Rosa commented that there are efforts to set up an on-site lab to facilitate sample collection and should this be successful, then a list of required data could be transmitted.

There was also interest in examining the relationship between body condition and breath analysis data. In the case of free-ranging animals, the nuchal area can be photographed at the time that exhaled breath samples are collected. Rowles noted that lung gas can also be obtained from fresh carcasses, but that it would be critical to seal the sample to prevent off-gassing.

Humpback whales

Falcone presented preliminary results of visual health assessments of North Pacific humpback whales (*Megaptera novaeangliae*) based on flank photos obtained during the SPLASH project in 2004. Flank photos of humpback whales from across the North Pacific were collected to assess rates of anthropogenic injury; the present study was designed to determine their utility in assessing other visual measures of health, which could then be analyzed for large-scale regional and temporal trends. A total of 1,091 photos, representing 730 unique individuals, were scored for five quality criteria and the following health and injury criteria: overall body condition, overall skin condition, superficial sloughing, "pock" marks, "bumps", ulceration/lesions, barnacles, condition of the dorsal fin, general degree of scarring, killer whale rake marks, evidence of serious injury and its possible cause. Preliminary analyses suggested that overall body condition improved over the course of the season, while overall skin condition declined. There was evidence of regional differences and temporal trends in the frequency of both "pock" marks and "bumps", types of body lesions that have been noted by researchers but not been formally described or explained. Results also suggested regional differences in the frequency with which barnacles were observed on the body and dorsal fin, as well as in the types of skin conditions most frequently observed. Work to date suggests that flank photos may be useful in studying health in humpback whales. These results will be further evaluated once the entire SPLASH flank data set has been analyzed.

Mattila commented on two types of skin lesions presented (rounded depressions and raised bumps of comparable size) that are quite prevalent in Hawaii and American Samoa but uncommon in the Gulf of Maine. These occurred on all body parts but appeared to be more prevalent below the water line. The rounded depressions were consistent with injuries expected from cookie cutter sharks. However, the similar size and position of the raised bumps made him question whether the two lesions were related.

Krahn described contaminant and fatty acid analyses underway using biopsy samples obtained during the SPLASH project. This is the first attempt to conduct such analyses on an ocean-basin scale for humpback whales and the results can ultimately be linked to the visual health analyses described above. Krahn also mentioned successful use of fatty acid analysis to age killer whales (see SC/59/SM3) and her plans to continue this research with known-age humpback whale samples from the Gulf of Maine. The ability to reliably age large whales from biopsy samples would inform studies of health and clarify the degree to which it varies with age.

Robbins summarized an on-going health assessment project focussing on Gulf of Maine humpback whales. Individuals in the Gulf of Maine are well-documented with respect to life history and fate, providing an strong foundation for the development of visual health assessment protocols. In this project, visual assessments of body condition were paired with biopsy sampling to provide independent information on nutritive parameters such as lipid content, lipid composition and fatty acids. Focal animals included free-ranging individuals of all classes in four seasons, as well as entangled animals and carcasses. In order to evaluate the consistency of biopsy results for nutritive health assessment, samples were obtained on multiple occasions from the same whales and also at various

depths from blubber of stranded animals. Photographs were taken as head-to-tail lateral series while alongside the whale. Preliminary analysis of photographic data suggested the nuchal and scapular areas to be most informative for body condition, with the latter also being sensitive to lactation state. Robbins also summarized on-going scar-based work to assess entanglement impacts in this species (see Robbins and Mattila 2001 for more details).

Based on the information presented, workshop participants agreed that body condition, skin characteristics and cyamid load appeared to hold promise for assessing health in this species. The morphology of the nuchal area, the scapula and the flanks were all considered potentially informative about body condition. Flank photographs were likely less informative than the other areas, but nevertheless routinely catalogued in some humpback whale populations. Therefore, there is value in developing body condition indices for flanks if they can be tied into historic archives. However, future studies should incorporate full lateral photographic sequences that capture the anterior body as well as the flanks and posterior views. Several angles and multiple photographs from the same individual were recommended to differentiate between subtle, normal variation (as in the scapular region). Carcass sampling was recommended to clarify inter-species differences in blubber depth and composition in the nuchal and scapular areas, as there was a suggestion that the pattern of subcutaneous fat loss in humpback whales is slightly different than in right and western gray whales. Participants considered SPLASH analysis protocols for skin condition and lesions to be useful, but suggested a few modifications. Humpback whale skin lesions reviewed at the workshop were most broadly classified as either raised or eroded, and all were of uncertain origin. It was noted that some skin irregularities may be age-specific (such as those referred to as “calf acne”). Direct sampling of lesions, whether from free-ranging or stranded animals, was recommended for more understanding of these discrete features. Falcone agreed to develop a modification of her scoring protocol for humpbacks, including examples.

GENERAL COMMENTS AND CONCLUSIONS

For endangered species, there is management value in being able to assess the health of free-ranging animals and to predict their fate. Some of the studies presented in this workshop were successful adaptations of visual techniques developed by Pettis et al. (2004). However, there were also differences between species that indicate the need for additional studies. For example, body condition was considered important for all species, but there appears to be differences in how changes in subcutaneous fat present among species, and some features (like the scapula) may also be more or less prominent depending on body position. It was further noted that compromised free-ranging animals can be difficult to study by visual techniques because they often present less of their body than other animals.

Participants noted the importance of judging image quality prior to scoring in order to ensure consistency and accuracy. Quality coding should take into consideration the percentage of the feature that is visible, as well as photographic factors such as focus, angle, distance and exposure. Health-related factors have a different appearance depending on the body part, or may be more prevalent on some body parts than others. Research should take into consideration the potential for body part specificity, as well as seasonality and age effects that may be important to fully understanding lesions and other health indicators. Although this workshop was not intended to address human impacts, participants noted the importance of linking health assessments to studies of entanglement and ship strike to improve inference into both.

None of the lesions presented during the workshop were identified to a known source or causative agent. High quality photographs may be adequate to distinguish among lesion types. However, veterinarians also recommended written descriptions of the grossly visible lesions using standard terminology. They provided a detailed list of recommended terms and also recommended the “Necropsy Handbook” (King et al. 2006) for further reference. However, they also recognized that terms used to describe lesions on carcasses and in microscopic analyses can not always be effectively applied to free-ranging animals at sea. Tissue samples taken directly from lesions will likely be necessary to determine their underlying cellular components and causative agent. This may be difficult for free-ranging animals, but participants agreed that some features may also be flagged for sampling from carcasses. Coordination with stranding networks will therefore be key to ground-truthing visual health assessments, evaluating the pathology underlying some of the visual conditions, and gathering data to more accurately describe some discrete features. A large whale necropsy protocol is well-established for right whales on the US east coast and this can be modified for application to other species and other areas. Rotstein has also developed a sampling kit suitable for biopsy and other types of sampling. He commented on the importance of documentation, including sample collection details and sample handling prior to arrival at the lab. If possible, control samples should be shipped with

"impacted" samples to establish a baseline. It was also recommended that field biologists develop a rapport with the pathologist that will be analyzing the samples.

An overriding theme of the workshop was the importance of building a dialog among researchers in a variety of disciplines and for comparative studies among species and areas. To facilitate this communication, a private web site was proposed to share information in a timely manner, including images and analytical results. Although one possible goal of the workshop had been to develop a standard data form for visual health assessments, it was agreed that this was not yet possible. Rather, participants agreed to move forward individually with plans to collaborate on standardizing techniques in the near future, likely during a follow-up meeting.

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